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Te[illegible] Report S[illegible] on the B[illegible]osystem-A[illegible]sphere Study (BOREAS)

[illegible]ll and Sara K. Conrad, Editors

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[illegible]AS TGB-1/TGB-3 CH_4 [illegible] over the

[illegible] and T.R. Moore

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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Sara K. Conrad, Editors

Volume 222

BOREAS TGB-1/TGB-3 CH_4 Chamber Flux Data over the NSA Fen

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National Aeronautics and
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November 2000

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BOREAS TGB-1, TGB-3 CH_4 Chamber Flux Data over the NSA-Fen

Jill L. Bubier, Tim Moore

Summary

The BOREAS TGB-3 team collected methane (CH_4) chamber flux measurements at the NSA fen site during May-September 1994 and June-October 1996. Gas samples were extracted approximately every 7 days from chambers and analyzed at the NSA lab facility. The data are provided in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TGB-01/TGB-03 CH_4 Chamber Flux Data over the NSA-Fen

1.2 Data Set Introduction

The Trace Gas Biogeochemistry (TGB)-01 and -03 teams collected chamber flux measurements at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) Fen site from May to September 1994 and April to late October 1996.

1.3 Objective/Purpose

The objectives of these measurements were:

- To examine the trace gas exchange between the atmosphere and the boreal wetland soils.
- To quantify CH_4 emissions from the range of peatland soils in the Nelson House area, as represented by a suite of peatlands in the Tower Fen (TF) complex.
- To identify environmental controls on CH_4 emission and the spatial and temporal variability associated with those controls, in order to improve the process models that describe exchanges of trace gases between the boreal ecosystem and the atmosphere.
- To examine the change in CH_4 flux associated with the evolution of palsas and peat plateaus into collapse, through thermal degradation of permafrost.
- To identify the role of plant associations, as integrators of the environmental controls, in determining CH_4 flux in order to provide a framework for extrapolating single-point CH_4 measurements from the chamber to the landscape scale.

1.4 Summary of Parameters

In the 1994 sampling season, CH_4 chamber flux measurements were taken from six sites. These sites were designated as collapse bog (CB), collapse fen (CF), TF, remote bog (RB), remote fen (RF), and zoltai fen (ZF).

In the 1996 sampling season, CH_4 chamber fluxes were measured at four subsites in the NSA fen. These sites were designated as CB, CF, TF, and ZF. A spur (1, 2, 3, or 4) further designates each collar location along the boardwalk at each subsite. The collar location is also designated by the microtopography, or dominant ground cover, of the collar location: palsa, hummock, hollow, lawn, open water at the edge of the collapse scars, brown moss, sphagnum, lichen.

1.5 Discussion

In 1994, CH_4 chamber flux measurements were taken at six subsites within the NSA fen site to determine the soil surface exchange rate of CH_4 at these locations. The locations represent the range of plant communities, water chemistry, and peatland types found in northern peatlands, including bog, rich fen, poor fen, and collapse scar (pH ranges from 3.8 to 7.2). The sampling collars were installed in the spring of 1994 by the McGill researchers (TGB-03), and measurements of CH_4 flux were made during and between the 1994 Intensive Field Campaigns (IFCs).

In 1996, chamber CH_4 flux measurements were taken at four subsites within the fen complex in the NSA to determine the soil surface exchange rates of CH_4 at these locations. A subset of the collars installed by the McGill researchers (TGB-03) was measured again from June until the end of October 1996. In addition, the University of New Hampshire (UNH) researchers (TGB-01) installed 15 collars in the fall of 1995; 9 additional collars were installed by the UNH researchers in the spring of 1996. CH_4 flux measurements began in early April 1996 and continued until the end of October 1996.

Two different types of data are presented:

- CH_4 flux measurements using the UNH collars.
- CH_4 flux measurements using the McGill University collars.

1.6 Related Data Sets

BOREAS TGB-01 CO2 and CH4 Chamber Flux data over the NSA
BOREAS TGB-01 CH4 Tower Flux data over the NSA
BOREAS TGB-03 CH4 and CO2 Chamber Flux Data over NSA Upland Sites
BOREAS TGB-01/TGB-03 NEE data over the NSA Fen
BOREAS TGB-01/TGB-03 Water Table and Peat Temperature data over the NSA Fen
BOREAS TGB-03 Plant Species Composition Data over the NSA Fen

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Jill L. Bubier
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University of New Hampshire

Dr. Patrick M. Crill
Research Associate Professor
University of New Hampshire

Dr. Tim R. Moore
Professor
McGill University

2.2 Title of Investigation

Magnitude and Control of Trace Gas Exchange in Boreal Ecosystems

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3. Theory of Measurements

Chamber fluxes measure the changes in mixing ratio of trace gases (CH_4) in a closed headspace over a period of time. This headspace is isolated from the atmosphere; therefore, we can quantify the exchange of material between the covered soil and the headspace.

4. Equipment

4.1 Sensor/Instrument Description

The CH_4 flux measurements were measured with PVC collars (26 cm in diameter) and chambers made from polycarbonate bottles (26 cm in diameter; 40 cm tall; area of exposure 0.053 m^2; Moore and Roulet, 1991). Bottles were covered with aluminum foil to reduce heating. The neck of each bottle was sealed with a rubber stopper that contained a glass tube with a rubber septum with a 1 m length of Tygon tubing attached to the top to minimize disturbance. Syringes were made of polypropylene syringes.

CH_4 was quantified with a Shimadzu 14A Gas Chromatograph (GC) or a Shimadzu Mini2GC with a flame ionization detector (FID) operated at 125 °C after separation on a HayeSepQ column at 40 °C using ultra-pure (99.999%) N_2 as a carrier gas flowing at 30 mL/min. Analog signals (0-1 V) from the detectors were digitized at 10 Hz with a Hewlett Packard (HP) 35000D A/D board and quantified and logged using HP ChemStation software. Chamber fluxes were accomplished with aluminum chambers manufactured at UNH and designed by Patrick Crill.

4.1.1 Collection Environment

The chamber fluxes were collected under all ambient environmental conditions. The GC analysis was completed at the Heritage North Museum Lab in Thompson, Manitoba.

4.1.2 Source/Platform

CH_4 flux collars were inserted into the peat approximately 4-6 inches. Chambers were set in a groove in the collars.

4.1.3 Source/Platform Mission Objectives

The ground supported the collars, which supported the chambers.

4.1.4 Key Variables

The key variable measured during the sampling period was CH_4 flux. Net ecosystem exchange of CO_2 (NEE) was measured at the same time along with temperature and water table position. Percent cover of vascular plant species and bryophyte species was also recorded for each collar.

4.1.5 Principles of Operation

The Shimadzu GC-14A is equipped with a FID and a thermal conductivity detector (TCD). The FID is used to detect CH_4 while the TCD is used to detect CO_2. The FID employs a hydrogen flame in an air atmosphere to burn components as they exit the column. In the flame, carbon-carbon bonds are fragmented so that various organic ions and free electrons exist. Application of a voltage across a collector electrode over the flame causes an ion current to flow that is amplified and then measured as the output signal. The TCD detects CO_2 by passing a sample in a helium carrier gas past metallic filaments with current flowing through them. The sample components with lower thermal conductivity than the helium carrier gas raise the filament temperature when they pass through. The signal output from the TCD is a measurement of the change in filament resistance caused by the temperature rise. The signal output from both the FID and TCD is for a data processor, integrator, recorder, or computer (Instruction Manual: GC-14A; Shimadzu Corporation, Kyoto, Japan).

The GC-MINI2 was equipped with a FID and operated in the same manner as the GC-14A FID.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument

The investigator manufactured collar and chambers.

Manufacturer of GC-14A FID/TCD and GC-MINI2:
Shimadzu Scientific Instruments, Inc.
7102 Riverwood Drive
Columbia, MD 21046
(410) 381-1227

4.2 Calibration

4.2.1 Specifications

Analyses were conducted with a Shimadzu FID-GC using a Porapak Q column. Nitrogen was used as the carrier gas and CH_4 standards of 2.349 ppmv were used to calibrate. Precision of the analysis (standard deviation as percent of the mean of 10-15 daily repetitions of the standard) was less than 1% of the standards. Fluxes between 0.1 and -0.1 mg/m^2/d were not detectable.

Signal peaks from the detectors were quantified with working standards calibrated against Canadian Atmospheric Environment Services (AES) certified primary standards acquired by the BOREAS project and a CO_2/ CH_4 standard of Niwot Ridge air prepared by National Oceanic and Atmospheric Administration (NOAA) Climate Monitoring and Diagnostics Laboratory (CMDL). Uncertainty in the standards' analyses on a given day ranged from 0.1 to 0.2%.

4.2.1.1 Tolerance

The sensitivity of the TCD is approximately 6,000 mV mL/mg. The FID's maximum sensitivity is 3 x10^{-12} g/s for diphenyl.

4.2.2 Frequency of Calibration

The instrument is calibrated on a daily basis. Standards are run generally before and after samples on a given day of analysis.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

A total of 124 PVC collars were placed along the moisture, chemistry, plant community, and permafrost gradients in the peatland complex, and were sampled in 1994. At four of the sites (bog collapse scar (BC), fen collapse scar (FC), TF, and ZF, boardwalks were installed spanning the environmental gradients to minimize disturbance. CH_4 was sampled at each of the collars once a week from early May through mid-September 1994 using a static chamber technique (Crill et al., 1988). Water was added to the groove in each collar before inserting the chamber in order to make an air-tight seal. Air samples were obtained from each chamber by inserting a polypropylene syringe into the Tygon tubing equipped with a three-way stopcock, pumping the piston four or five times to mix air in the chamber before a 60-mL sample was drawn. A 10-mL sample was taken from the 60-mL syringe using the three-way stopcock. Five 10-mL samples were taken at 4-minute intervals over a 20-minute period. Samples were returned to a laboratory in Thompson and analyzed for CH_4 within 4-6 hours of collection. After analysis, the syringes were disassembled and allowed to equilibrate with ambient air. Syringe barrels and plungers were reassembled immediately before sampling.

The 1996 chamber fluxes are determined by analysis of concentrations of methane (CH_4) in a time series of grab samples of headspace over the ground surface enclosed by a clear chamber covered in an opaque shroud to prevent light from entering the chamber. For the TGB-01 collars, the NEE chambers were used. The chambers were 0.3660 m^2 in area and were either 0.905 m or 0.045 m in height. For the TGB-03 collars, chambers were made of polycarbonate bottles (0.026 m in diameter; 0.040 m tall; area of exposure 0.053 m^2) and were covered with aluminum foil to reduce heating. The neck was sealed with a rubber stopper that contained a glass tube with a rubber septum. Tygon tubing (1 m in length), equipped with a three-way stopcock, was attached to the top of each chamber to allow sampling at a distance that would minimize disturbance. TGB-03 collars were made of PVC tubing. The rim of the collars were routed with a groove that was filled with water when the chambers were put in place in order to create an air tight seal. TGB-01 collars were made of aluminum and were also designed with a trough for creating an air tight seal.

For both types of chambers and collars, the chamber was placed on the trough of a collar imbedded in the ground. Water was added to the trough of the collar to create an airtight seal. Five 60-mL samples were removed from the headspace with polypropylene syringes and polycarbonate/nylon stopcocks at 4-minute intervals for 20 minutes or at 2-minute intervals for 10 minutes (five samples per chamber). Samples were returned to the Heritage North Museum lab in Thompson, Manitoba, and analyzed for CO_2 and CH_4, using gas chromatography within 12 hours after collection.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

1994 TGB-03 Collars:

The area of exposure for each collar and chamber was 0.053 m^2. The 100 collars were placed so as to cover the environmental gradients in the TF complex, an area approximately 6 km^2. Global Positioning System (GPS) coordinates based on the North Amercian Datum of 1983 (NAD83) for the major sampling locations are:

Site	NLat	SDev	WLon	SDev	Elev	SDev
Collapse Bog (CB)	55°55'4.931"	2.75	98°25'5.294"	1.18	217.20	3.86
Collapse Fen (CF)	55°54'59.959"	5.60	98°25'6.109"	1.90	218.40	7.62
Zoltai Fen (ZF)	55°55'5.477"	2.07	98°25'26.396"	1.29	217.10	3.11

1996 TGB-01 Collars:

Collapse Bog (CB) collars were located in a small, circular collapse scar (75 m diameter) almost completely surrounded by permafrost peat plateau, behind the generator shed. Three spurs were located perpendicular to the boardwalk. Spur 1 was adjacent to the moat, or open water lagg area; spur 2 was in a hummock-hollow area; and spur 3 was in the center of the collapse scar. In addition to the collars in the collapse scar, this subsite had two collars on the palsa (frozen peat plateau) adjacent to the collapse scar. Collar designations were as follows:

```
CB1moat   = collapse bog, spur 1, moat
CB2hk     = collapse bog, spur 2, hummock
CB2hw     = collapse bog, spur 2, hollow
CB3hk     = collapse bog, spur 3, hummock
CBpalmoss = collapse bog, palsa, moss
Cbpallich = collapse bog, palsa, lichen
```

Collapse Fen (CF) collars were located in a small, linear collapse feature that was east of and accessed from the main trail to the tower hut. Four spurs were located perpendicular to the main boardwalk. Spur 1 was located adjacent to the moat; spur 2 was in a uniform lawn of Sphagnum riparium; spur 3 was in a small treed ridge; and spur 4 was on the far edge of the collapse scar where the influence of groundwater was apparent. Collar designations were as follows:

```
CF1moat  = collapse fen, spur 1, moat
CF2lwn   = collapse fen, spur 2, lawn
CF3hka   = collapse fen, spur 3, hummock (a)
CF3hkb   = collapse fen, spur 3, hummock (b)
CF4bmoss = collapse fen, spur 4, brown moss
CF4sph   = collapse fen, spur 4, sphagnum
```

Tower Fen (TF) collars were located along the boardwalk to the micrometeorological tower in the NSA fen. Four spurs were located perpendicular to the main boardwalk. Spur 1 was just beyond the moat at the beginning of the boardwalk in a treed area of tamarack (Larix laricina), spur 2 was in a tall shrub zone (Betula glandulosa), spur 3 was in a low shrub zone just before the hut, and spur 4 was just beyond the hut in a mixed low shrub/sedge zone. Collar designations were as follows:

```
TF1hk = tower fen, spur 1, hummock
TF2hk = tower fen, spur 2, hummock
TF2hw = tower fen, spur 2, hollow
TF3hk = tower fen, spur 3, hummock
TF3hw = tower fen, spur 3, hollow
TF4hw = tower fen, spur 4, hollow
```

Zoltai Fen (ZF) collars were located in a sedge-dominated (Carex spp.) fen area of the peatland complex, north of the fen tower, and accessed from Rt. 391. Three spurs were located perpendicular to the main boardwalk. Spur 1 was on a treed ridge; spur 2 was in a shrub-dominated hummock-hollow area; and spur 3 was in a wet, sedge-dominated area near the edge of a palsa. Collar designations were as follows:

```
ZF1hk    = zoltai fen, spur 1, hummock
ZF2hk    = zoltai fen, spur 2, hummock
ZF2hw    = zoltai fen, spur 2, hollow
ZF3bmoss = zoltai fen, spur 3, brown moss
ZF3hw    = zoltai fen, spur 3, hollow (Sphagnum)
ZF3hk    = zoltai fen, spur 3, hummock (Sphagnum)
```

1996 TGB-03 Collars:

For chamber CH_4 flux data from the McGill collars, the collars were the same as those sampled by TGB-03 in 1994. Major locations and spurs are the same as for the UNH collars described above. Microtopography for the McGill collars is designated as:

- Hummock
- Hollow
- Lawn (uniform area with little microtopography)
- Carpet (uniform area with water table closer to the peat surface than in lawn areas, peat is often a floating mat)
- Pool (water table above peat surface; submerged bryophytes, and Carex spp. or other emergent vascular plants present in collars)
- Moat (open water area or lagg at edge of peatland)

Collapse Fen (CF) location and spurs are the same as for the UNH collars described above. McGill collars are as follows:

```
FC4p16    = collapse fen, spur 4, pool, collar 16
FC4p17    = collapse fen, spur 4, pool, collar 17
FC4p16new = collapse fen, spur 4, pool, collar 16 relocated to new
            position on 22-August-1996 because vegetation was dying
            within the collar
FC4p17new = collapse fen, spur 4, pool, collar 17 relocated to new
            position on 22-August-1996 because vegetation was dying
            within the collar
FC4p19    = collapse fen, spur 4, pool, collar 19
FC4p20    = collapse fen, spur 4, pool, collar 20
FCm3f     = collapse fen, moat spur 1, collar 3 floating
FCm2f     = collapse fen, moat spur 1, collar 2 floating
FCm1f     = collapse fen, moat spur 1, collar 1 floating
```

Tower Fen (TF) location and spurs are the same as for the UNH collars described above. McGill collars are as follows:

```
TF4c16 = tower fen, spur 4, carpet, collar 16
TF4n17 = tower fen, spur 4, lawn, collar 17
TF4c18 = tower fen, spur 4, carpet, collar 18
TF4n19 = tower fen, spur 4, lawn, collar 19
TF4c20 = tower fen, spur 4 lawn, collar 20
TF3w11 = tower fen, spur 3, hollow, collar 11
TF3k12 = tower fen, spur 3, hummock, collar 12
TF3w14 = tower fen, spur 3, hollow, collar 14
TF3w15 = tower fen, spur 3, hollow, collar 15
TFm1f  = tower fen, moat, collar 1 floating
TFm2f  = tower fen, moat, collar 2 floating
TFm3f  = tower fen, moat, collar 3 floating
```

Zoltai Fen (ZF) location and spurs are the same as the UNH collars above. McGill collars are as follows:

```
ZF3k11 = zoltai fen, spur 3, hummock, collar 11
ZF3new = zoltai fen, spur 3, new collar
ZF3p15 = zoltai fen, spur 3, pool, collar 15
ZFmike = zoltai fen, new spur used by Mike Waddington in 1994
         (Carex rostrata, C. aquatilis lawn)
ZF2w8  = zoltai fen, spur 2, hollow, collar 8
```

7.1.2 Spatial Coverage Map

None given.

7.1.3 Spatial Resolution

The 24 UNH collars spanned the full range of hydrologic, plant community, and water chemistry gradients found in the larger peatland complex in order to capture the spatial variability in CH_4 fluxes. The 26 1996 McGill collars were placed along the same gradients with an emphasis on the wet end of the moisture gradient in order to resample the 1994 sites that exhibited the highest CH_4 fluxes.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

CH_4 flux, water table, and peat temperature measurements were made from mid-May through mid-September 1994. The chamber CH_4 flux measurements for 15 of the UNH collars were made from 15-April-1996 to 23-October-1996. The chamber CH_4 flux measurements for the other nine UNH collars were made 15-June-1996 to 23-October-1996. Chamber CH_4 flux measurements for the McGill collars were made from 03-June-1996 to 22-October-1996.

7.2.2 Temporal Coverage Map

Not applicable.

7.2.3 Temporal Resolution

CH_4 flux measurements were made once at week at each of the 124 collars throughout the 1994 season. The chamber CH_4 flux measurements for 15 of the UNH collars were made approximately every 7 days from 15-April-1996 to 23-October-1996. The chamber CH_4 flux measurements for the other nine UNH collars were made approximately every 7 days from approximately 15-June-1996 to 23-October-1996. Chamber CH_4 flux measurements for the McGill collars were made approximately every 7 days from 03-June-1996 to 22-October-1996.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
COLLAR_ID
AIR_TEMP
CH4_FLUX
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
COLLAR_ID	A TGB designation for the chamber collar site.
AIR_TEMP	The air temperature.
CH4_FLUX	Methane flux.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
COLLAR_ID	[none]
AIR_TEMP	[degrees Celsius]
CH4_FLUX	[micromoles][meter^-2][second^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	Supplied by BORIS
SUB_SITE	Supplied by BORIS
DATE_OBS	Investigator
COLLAR_ID	Investigator
AIR_TEMP	Not specified
CH4_FLUX	GC-FID
CRTFCN_CODE	Supplied by BORIS
REVISION_DATE	Supplied by BORIS

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-FEN-FLXTR	NSA-FEN-FLXTR	None	None	None	None
SUB_SITE	TGB03-FLX01	TGB03-FLXZF	None	None	None	None
DATE_OBS	09-MAY-94	21-OCT-96	None	None	None	None
COLLAR_ID	CB1c01	ZFC-03	None	None	None	None
AIR_TEMP	-5	28	None	None	None	Blank
CH4_FLUX	-6.9921875	1.39266204	-999	-888	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	14-APR-97	29-APR-98	None	None	None	None

```
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
```

```
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
--------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of sample data records from a selected file on the CD-ROM:

```
SITE_NAME,SUB_SITE,DATE_OBS,COLLAR_ID,AIR_TEMP,CH4_FLUX,CRTFCN_CODE,REVISION_DATE
'NSA-9BS-T03BS','TGB03-FLXBM',07-JUN-94,'C-BM-05',9.04900463,0,'CPI',04-APR-97
'NSA-9BS-T03BS','TGB03-FLXBM',07-JUN-94,'C-BM-06',27.877662,-.00425,'CPI',
04-APR-97
```

8. Data Organization

8.1 Data Granularity

CH_4 flux measurements for a given site on a given day.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

$R_f = C_{std} / A_{std}$
$C_s = R_f * A_s$
R_f = Response factor
A_{std} = Standard peak area
C_{std} = Concentration of the standard
C_s = Concentration of the sample
A_s = Peak area of sample

CH_4 concentrations were calculated from the average of 10 peak areas of known CH_4 standards. The response factor was calculated as the concentration of the known standard divided by the average of 10 standard peak areas. The peak area of the unknown sample was multiplied by the response factor.

The flux calculations were made by fitting a regression curve to the time series of CH_4 concentrations. The flux rate of a gas is calculated using the following equation:

$$\text{Flux(mg/m}^2\text{/d)} = \text{ppmv/min} * (\text{P/R*g/mol of the gas}) * (1/T)*V_c>/A_c * (1000\text{mg/g}*1440\text{min/d})$$

where: P = pressure in atmospheres
$R = 8.2054 \times 10^{-5>}\ m^3atm/mol/K$

gases: CH_4 = 16 g/mol
T = degrees K of the chamber
V_c = chamber volume in m^3
A_c = chamber area in m^2

$$V_c=((E/100 \times 0.047 \times 1000) + V_t$$

V_c = volume of the chamber
V_t = volume of the top narrow part of chamber = 1.4
E = height of cylindrical part of chamber in cm

9.2 Data Processing Sequence

9.2.1 Processing Steps

The peak areas were taken directly from the HP ChemStation reports from the GC. They were entered into spreadsheets and the concentrations were calculated by the formulas in Section 9.1. The spreadsheets then automatically calculate the flux using the formulas in Section 9.1.

The flux equation included the slope of the regression line of the five samples; the height and volume of the chamber; air temperature (see above). Fluxes were calculated by linear regression of the concentration change in the five samples. If one sample deviated from the line, the flux was recalculated without the outlier. The correlation coefficient of the regression had to be significant to the 95% confidence limit for n=4 or 5 (r^2 = 0. 95 or 0.87); otherwise the sample was rejected. Sites with ebullition were kept in the data set even if a large increase was observed between two of the samples as long as the correlation coefficient was still significant at $p < 0.05$.

9.2.2 Processing Changes

Not applicable.

9.3 Calculations

At sites where oxidation of CH_4 occurred, the flux needed to start at or near ambient levels of CH_4 and be drawn down below ambient. The correlation coefficient also had to show significant correlation. If these criteria were not met, the flux was determined to be below our minimal detectable flux and was regarded as a 0 flux rate. If an efflux of CH_4 was measured at any of these sites, the data were eliminated.

For sites where CH_4 was known to have a positive flux (from the soil into the atmosphere), the regressions of the time series were expected to have an r^2 of greater than 0.85 for n=5. If this was not the case with five data points, then one or at most two points might be dropped to get a better fit. The r^2 would have to be greater than 0.92 for n=4, and 0.96 for n=3 (90% confidence interval). If the fit was not good enough (r^2 less than required for 90% confidence interval), the data were eliminated.

If -888 is present in the data set, it represents a measurement that was taken but discarded for some reason. If -999 is present, then no data were taken.

9.3.1 Special Corrections/Adjustments

Not applicable.

9.3.2 Calculated Variables

Not applicable.

9.4 Graphs and Plots

None given.

10. Errors

10.1 Sources of Error

One source of error was disturbance while sampling the chamber. If the peat or the chamber was disturbed, a large pulse of CH_4 was emitted. These samples were eliminated from the data set and the number -9666 was recorded to note the error. If no data were taken at that collar on a particular date, -999 was recorded to denote missing data. Field sampling error could also account for some error in the concentration of the syringe samples:

- Not flushing the sampling line from the chamber before sampling could cause dilution of the sample with air from the last sampling time.
- Not completely closing the syringes or having them come open during transport will cause dilution from ambient air.
- Placing the chamber down with much force can change the pressure inside the chamber to other than ambient and can effect the mechanisms and processes producing/taking up CH_4.

(Errors such as these would have been written down in the lab/field books, and those data have been edited out.) The analytical precision of the GCs is 0.2% for CH_4.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Each flux measurement has been verified by checking the calculations in the spreadsheets and assessing the slope and intercept for the linear regression.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

The analytical precision of the GCs is 0.2% for CH_4.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

The analytical precision of the GCs is 0.2% for CH_4.

11.2 Known Problems with the Data

None given.

11.3 Usage Guidance

The manuscript by Bubier et al. (1995) contains predictive relationships developed from data described in this document.

11.4 Other Relevant Information

Not applicable.

12. Application of the Data Set

The chamber flux data can be used in connection with the tower flux data to determine the CH_4 exchange between the atmosphere and the boreal soils. The plant community and water table and temperature data can be used in comparison with the flux data to determine controls on the fluxes for a certain biome. The chamber CH_4 flux data can also be compared with chamber NEE data to examine the relationship between net ecosystem productivity and CH_4 flux.

13. Future Modifications and Plans

This data set is in its draft format.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The CH_4 chamber flux data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Not applicable.

17.2 Journal Articles and Study Reports

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Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Sjors, H. 1950. On the relation between vegetation and electrolytes in Swedish mire waters. Oikos, 2, 241-258.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

```
AES      - Atmospheric Environment Services, Canada
ASCII    - American Standard Code for Information Interchange
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
BP       - Beaver Pond site, NSA
CB       - collapse bog subsite, NSA fen complex
CD-ROM   - Compact Disk-Read-Only Memory
CF       - Collapse Fen subsite, NSA fen complex
CMDL     - Climate Monitoring and Diagnostics Laboratory
DAAC     - Distributed Active Archive Center
ECD      - Electron Capture Detector
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
FID      - Flame Ionization Detector
GC       - Gas Chromatograph
GIS      - Geographic Information System
GPS      - Global Positioning System
GSFC     - Goddard Space Flight Center
HTML     - HyperText Markup Language
IFC      - Intensive Field Campaign
IRGA     - Infrared Gas Analyzer
LI-6200  - LI-COR portable photosynthesis system
NAD83    - North American Datum of 1983
NASA     - National Aeronautics and Space Administration
NEE      - Net Ecosystem Exchange of CO2
NSA      - Northern Study Area
OBS      - Old Black Spruce, NSA
OJP      - Old Jack Pine, NSA
ORNL     - Oak Ridge National Laboratory
PANP     - Prince Albert National Park
SSA      - Southern Study Area
TCD      - Thermal Conductivity Detector
TF       - Tower Fen subsite, NSA fen complex
UNH      - University of New Hampshire
URL      - Uniform Resource Locator
YJP      - Young Jack Pine, NSA
ZF       - Zoltai fen subsite, NSA fen complex
```

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The BOREAS TGB-3 team collected methane (CH_4) chamber flux measurements at the NSA fen site during May-September 1994 and June-October 1996. Gas samples were extracted approximately every 7 days from chambers and analyzed at the NSA lab facility. The data are provided in tabular ASCII files.

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